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STATISTICAL ANALYSIS OF THE SUSTAINABLE AGRICULTURAL LANDS USE AND FERTILE IRREVERSIBLE LOSS OF SOIL WHICH ARE WASHING FROM VERSANTS OF RURAL AREA

Olesea COJOCARU[1], Valerian CERBARI[2], Feodor FILIPOV[3], Teodor RUSU[4], Ileana BOGDAN[4], Esmeralda CHIORESCU[3], Paula Ioana MORARU[4], Adrian POP[4]

[1]Agrarian State University of Moldova, 50 Mircesti Street, 2049, Republic of Moldova
[2]Institute of Pedology, Agrochemistry and Soil Protection „Nicolae Dimo”, 100 Ialoveni Street, 2070, Republic of Moldova
[3]„Ion Ionescu de la Brad” University of Agricultural Sciences and Veterinary Medicine Iasi, 3 Mihail Sadoveanu Street, 700490, Romania
[4]University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, 3-5 Manastur Street, 400372, Romania

Corresponding author email: o.cojocaru@uasm.md

Abstract

The developing sustainable agriculture (ecological) promoting sustainable production systems, diversified and balanced, in order to prevent the pollution of the crop and the environment. In order to extend the system of sustainable agriculture in the Republic of Moldova, national legislation has been established on the production, processing and capitalizing on agri-food products and special attention is given to soil quality - plant life. The aim and tasks of rural research were to: Determine the washed soil mass on the slopes based on the average statistical parameter data depending on the chemical properties (humus content) and make the necessary calculations. From the analysis of the data on soil losses through washing it is observed that they are in close connection with the degree of erosion. By comparing these data to the result we obtained: not eroded soil - 92 cm; poorly eroded soil - 76 cm; moderately eroded soil - 47 cm; strongly eroded soil - 40 cm; mollic delluvial soil - 132 cm; typical delluvial soil - 193 cm.

Key words*: agricultural land, irreversible loss of soil, humifer profile, statistical analysis, sustainable use.*

INTRODUCTION

Soil is an essential resource for all cultivated plants, being not only a support for plant roots, but also a reservoir of essential nutrients necessary for plant growth. Due to the widespread practice of intensive farming, the soil is threatened by a number of status factors such as erosion, loss of nutrient reserve, pollution, aridization, decreased fertility etc. Sustainable development means first and foremost to ensure a better quality of life for people, both now and for future generations. Sustainable development also means recognizing that the economy, the environment and social well-being are interdependent, especially in the conditions of an environment that is always under enormous anthropogenic pressure. All this requires a robust, healthy local economy able to create the means to meet these food needs for as long as possible (Blaga et al., 2005; Cerbari, 2010; Mureleanu et al., 1992).
Agriculture at the orchard stage of the development of human society implied a permanent competition between the ecological and the economic component. For these reasons, with the introduction of soil cultivation and sowing, agriculture could already be defined as a planned, economical, energy consumer system to increase productivity at the surface unit (Blum et al., 1994; Neamțu, 1996).
The largest areas of land damaged by landslides are in the districts: Calarasi - 3084 ha, Ungheni - 2094, Hancesti - 1364 ha, Straseni - 1115 ha, Telenesti - 1176 ha (Ghid practic, MDT-ACSA, 2015).
Agriculture has a major contribution to the sustainable development of the economy and society through the economic and social opportunities it confers on current and future generations. Agriculture is not just the support for biomass production, or the sector that

provides food for humanity, but it is the very basis of life's existence. At the same time, however, agriculture must also take responsibility for protecting the soil and other environmental resources that it can degrade. Without a doubt, the production of food depends on many factors, but the quality of the land and, implicitly, the soil are decisive (Blaga et al., 2005; Cerbari, 2010; Montgomery, 2007; Neamțu, 1999; Rusu et al., 2009).

MATERIALS AND METHODS

Agricultural land of any kind, irrespective of its destination, the titles on the basis of which it is owned or the public or private domain, to which it belongs, constitutes the land fund of the Republic of Moldova.

According to the pedogeographical district of the territory of Moldova, elaborated by A. Ursu, the research object in the rural area, chosen to study the loss of fertile soil in the hilly area of the Middle Prut, is located in 13a district with ordinary and the dustycarbonate chernozems (Ursu et al., 1986; Ursu, 2011; Șișov et al., 2004).

The soils in the area from the left side of the Prut river, according to the results of our experiments (Cerbari, 2010; Cerbari et al., 2010; Cojocaru, 2015; Ursu, 2011) and other researchers (Mureleanu et al., 1992; Vilain, 2003; Rusu et al., 2009; Ursu et al., 1986; Dokuceaev, 1949) are characterized by a favorable loam-clayed or silty (rarely) dusty-sandy.

Thus, the clay powders are vulnerable to crust formation and erosion. Coarse sandy clay and, in particular, coarse sandy-clay are very vulnerable to compaction, having also under natural conditions high values of apparent density and of the degree of compaction and low values of total porosity, in agreement therewith, have lower water retention capacity of the plants and lower permeability, poor aeration and less favorable mechanical properties, especially cohesion and high shear resistance, especially at low humidity.

Potential erosion of soils located on different segments of the slope in the rural area of the Negrea commune was determined under standard conditions on 3 m^2 leakage control plots (Cojocaru, 2015).

RESULTS AND DISCUSSIONS

It is necessary to emphasize that any eroded soil is a result of a balance between the permanent process of pedogenesis and the process of its physical deterioration through erosion (Cerbari et al., 2010; Arinușkina, 1970).

In the case of inactive land (fallow ground) the denudation processes (natural or geological erosion) are slow (Constantin, 2011; Moțoc, 1963; Neamțu, 1999; Ursu et al., 1986) and soils of varying degrees of evolution are formed.

Soil erosion (accelerated erosion) is related to the influence of the anthropic factor on the land fund and has now become the main process of deterioration, degradation and desertification of agricultural land (Arinușkina, 1970; Blum et al., 1994; Cerbari, 2010; Montgomery, 2007; Moțoc, 1963).

The assessment of the state of degradation of agricultural land due to water erosion was carried out in Romania first by Moţoc M., Luca Al. and others (Constantin, 2011; Montgomery, 2007; Mureleanu, 1992; Neamțu, 1999) and in Moldova and other countries the study of eroded soils and the development of anti-erosion technologies was carried out by Zaslavski M.N. and others (Ursu, 2011; Dokuceaev, 1949; Konstantinov, 1987; Voloșiuk, 1978; Zaslavskii, 1966; Șișov et al., 2004).

Field measurements of penetration resistance of layers and horizons of ordinary chernozems at moisture close to field capacity showed low levels for the recently arable layer and comparatively large for the underlying posture layers, which increase the vulnerability of soils to erosion.

Determination of the washed soil mass on the slopes was performed on the basis of the average statistical data and the necessary calculations (Tables 1-6).

By comparing the average statistical thickness of the humifer soil profile of the not eroded soil with the appropriate thickness of eroded soils it was established decreasing thickness humifer profile eroded soils and increase its delluvial soils. The thickness of the loose soil layer for soils with different degrees of erosion is as follows:

poorly eroded - 16 cm; moderately eroded - 45 cm; strongly eroded - 52 cm (Cojocaru, 2015).

Table 1. The average statistical parameters of the humus content of *ordinary not eroded chernozems* in rural areas (Cojocaru, 2015)

Genetic horizon and average depth, cm	X	s	V, %	m	P, %	n
Humus content, %						
Ahp: 0-26	3.31	0.31	9.4	0.16	4.8	4
A+Bhp: 26-38	2.84	0.30	10.6	0.16	5.6	4
Ahbkp: 38-59	3.23	0.14	4.3	0.07	2.2	4
Bhk1: 59-72	2.02	0.17	8.4	0.09	4.5	4
Bhk2: 72-92	1.43	0.03	2.1	0.02	1.4	4
BCk1: 92- 111	0.72	0.20	27.9	0.10	13.9	4
BCk2: 111-130	0.57	0.09	15.8	0.05	8.8	3
Ck: > 130	0.41	0.04	9.8	0.02	4.9	3

Table 2. The average statistical parameters of the humus content of *ordinary poorly eroded chernozems* in rural areas (Cojocaru, 2015)

Genetic horizon and average depth, cm	X	s	V, %	m	P, %	n
Humus content, %						
Ahkp: 0-19	2.93	0.25	8.5	0.11	3.8	5
(A+B)hkp: 19-34	2.47	0.32	12.9	0.14	5.7	5
Ahbkp: 34-55	2.90	0.46	15.9	0.21	7.2	5
Bhk2: 55-76	1.44	0.27	18.8	0.12	8.3	5
BCk1: 76-101	0.73	0.23	31.5	0.10	13.7	5
BCk2: 101- 127	0.52	0.14	26.9	0.07	13.5	4
Ck: > 127	1.61	0.07	17.5	0.04	10.0	4

Table 3. The average statistical parameters of the humus content of *ordinary moderately eroded chernozems* in rural areas (Cojocaru, 2015)

Genetic horizon and average depth, cm	X	s	V, %	m	P, %	n
Humus content, %						
Abhkp: 0-24	2.31	0.35	15.2	0.14	6.1	6
Abbhk: 24-47	2.41	0.30	12.5	0.12	5.2	6
BCk1: 47-68	0.84	0.17	20.2	0.07	8.3	6
BCk2: 68-92	0.70	0.12	17.1	0.05	7.1	5
Ck: > 92	0.30	0.10	33.3	0.06	20.0	3

Table 4. The average statistical parameters of the humus content of *ordinary strongly eroded chernozems* in rural areas (Cojocaru, 2015)

Genetic horizon and average depth, cm	X	s	V, %	m	P, %	n
Humus content, %						
Bhkp: 0-22	1.74	0.41	23.6	0.14	8.1	9
Bbhk: 22-40	1.77	0.41	23.2	0.14	7.9	9
BCk1: 40-56	0.81	0.13	16.1	0.04	4.9	9
BCk2: 56-80	0.64	0.03	4.7	0.02	3.1	3
Ck: > 80	0.32	0.05	15.6	0.03	9.7	3

Table 5. The average statistical parameters of the humus content of *mollic delluvial soils (izohumic cumulative)* in rural areas (Cojocaru, 2015)

Genetic horizon and average depth, cm	X	s	V, %	m	P, %	n
Humus content, %						
Ahp1: 0-26	2.89	0.12	4.2	0.07	2.4	3
Abh1: 26-62	3.08	0.12	3.9	0.07	2.3	3
Bh1: 62-90	2.27	0.10	4.4	0.06	2.6	3
Bh2k: 90-132	1.38	0.13	9.4	0.08	5.8	3
BCk: > 132	0.96	0.27	28.1	0.16	16,7	3

Table 6. The average statistical parameters of the humus content of *typical delluvial soils (typical cumulative)* in rural areas (Cojocaru, 2015)

Genetic horizon and average depth, cm	X	s	V, %	m	P, %	n
Humus content, %						
I hkp: 0-23	2.45	0.2	8.2	0.1	4.1	3
II hkp: 23-46	2.29	0.1	4.4	0.1	2.6	3
III hkp: 46-69	2.45	0.5	20.4	0.3	12.2	3
Ahbk: 69-117	3.33	0.2	6.0	0.1	3.0	3
Bhk1: 117-148	2.23	0.5	22.4	0.3	13.5	3
Bhk2: 148-193	1.41	0.2	14.2	0.1	7.1	3
BCk: 193-213	0.89	0.1	11.2	0.1	6.7	3

Using the average apparent density and surface data of each eroded soil category, the following fertile losses were established for each soil unit on the slopes studied in the rural area:

a) *poorly eroded*: 183744 t or 1920 t/ha;
b) *moderately eroded*: 641520 t or 5400 t/ha;
c) *strongly eroded*: 475 904 t or 6760 t/ha.

Total were washed from the investigated slopes from the village of Negrea - about 1.3 million tons of fertile soil.

At the same time in the evaluated and researched area, to the formation of delluvial soils was retained following amount of fertile soil washed from the slopes:

d) *mollic delluvial soils*: 57 600 t or 4800 t/ha;
e) *typical delluvial soils*: 132 613 t or 13130 t/ha.

Total formation delluvial soils in the village Negrea about 0.2 million tons of pedolite was retained.

The irreversible losses of humic soil at the moment are extremely high, making up about 1.1 million tonnes of fertile soil.

These losses were calculated as the difference between the total amount of washed soil and the amount deposited in the depressions of the Negrea receiving basin, forming delluvial soils. The total area of the erosion-affected land in the studied area is 284.9 ha or 83.1% of the total area.

It appears that on each hectare affected by erosion on average, irreversibly historical about 3.9 thousand t/ha of humic soil was lost.

Delluvial soils, due to its location on the specific relief elements (depressions, valleys) partially diminish the negative effects of erosion processes and increases the stability of landfills.

It is worth mentioning that in the hilly area of the Middle Prut the valleys are narrow, their surface is small, delluvial soils are not widespread and their land stabilization effect is not high.

Mollic delluvial soils *(izohumic cumulative)* are much more fertile than eroded soils, but increased erosion on the slopes after deforestation of multiannual plantations leads to their intensive clumping with low humid pedolithic deposits and to the accelerated diminishing of their agricultural production capacity.

The large historical irreversible losses of washed material on the slopes, the small stabilizing effect of landscapes by the sloping soils, the high vulnerability of soils to conditioned denudation processes, first of all, the peculiarities of their texture place erosion as a degradation factor and deterioration of the soil cover in the hilly area of the Middle Prut.

This particularity of the territory must be taken into account in the re-planning of the lands of the pedological district 13a, and in the design and implementation of the necessary measures to combat the erosion processes (Cerbari, 2010; Cojocaru, 2015; Ursu, 2011).

Conservation and maintenance of natural soil fertility has been and is being supported and promoted by researchers and specialists, taking into account the current requirements for the development of sustainable agriculture.

Sustainable agriculture must be economically viable, „healthy" environmentally and socially fair (Blaga et al., 2005; Vilain, 2003; Rusu et al., 2009).

CONCLUSIONS

At the basis of the erosion control activities, should be made mandatory „ecologic limit of the territory" that characterizes the limit of self-generation of the environment.

When re-planning the use of the agricultural land fund of the reception basins in the hill area of the Middle Prut, it is recommended that these lands be used predominantly under the vineyard plantations.

A total of 1.3 million tonnes of fertile soil were washed from the slopes of the Negrea reception basin.

In total, the formation of the delluvial soils on the territory of the Negrea about 0.2 million t of pedolite was retained.

The irreversible losses of humic soil at the moment are extremely high, making up about 1.1 million tonnes of fertile soil.

The large historical irreversible losses of washed material on the slopes, the small stabilizing effect of landscapes by the sloping soils, the high vulnerability of soils to conditioned denudation processes, first of all, the peculiarities of their texture place erosion on the forefront as a degradation factor and deterioration of the soil cover in the hilly area of the Middle Prut.

Therefore, a number of measures are needed to improve the existing serious problems, welcome by both the government and the local authorities and communities.

Agriculture at the orchard stage of the development of human society implied a permanent competition between the ecological and the economic component.

For these reasons, with the introduction of soil cultivation and sowing, agriculture could already be defined as a planned, economical, energy consumer system to increase productivity at the surface unit.

Consequently, there must be a major interest in innovative technologies, sustainable land use systems that prevent or minimize soil degradation, restore productive capacity and the vital processes of degraded soils.

According to the results of the evaluation and examination of the quality of ordinary chernozems in the rural area of Negrea, the finding of the situation in the field of sustainable use of local agricultural land is deplorable.

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